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CNF			**Contact sensation in the synthetic environment using the ISU force reflecting exoskeleton** *Luecke, G.R.; Chai, Y.-H.* Virtual Reality Annual International Symposium, 1997., IEEE 1997 , 1997 , Page(s): 192 -198, 218
CNF			**Force propagation models in laparoscopic tools and trainers** *Payandeh, S.* Engineering in Medicine and Biology Society, 1997. Proceedings of the 19th Annual International Conference of the IEEE Volume: 3 , 1997 , Page(s): 957 -960 vol.3
CNF			**Haptic interface for virtual reality based minimally invasive surgery simulation** *Baumann, R.; Clavel, R.* Robotics and Automation, 1998. Proceedings. 1998 IEEE International Conference on Volume: 1 , 1998 , Page(s): 381 -386 vol.1
CNF			**Tele-teaching by human demonstration in virtual environment for robotic network system** *Kunii, Y.; Hashimoto, H.* Robotics and Automation, 1997. Proceedings., 1997 IEEE International Conference on Volume: 1 , 1997 , Page(s): 405 -410 vol.1

CNF **Haptic interaction using a PUMA560 and [illegible] ISU force reflecting exoskeleton system**
Luecke, G.R.; Chai, Y.-H.
Robotics and Automation, 1997. Proceedings., 1997 IEEE International Conference on
Volume: 1 , 1997 , Page(s): 106 -111 vol.1

CNF **Haptic display of visual images**
Shi, Y.; Pai, D.K.
Virtual Reality Annual International Symposium, 1997., IEEE 1997 , 1997 , Page(s): 188 -191

CNF **Imposing motion constraints to a force reflecting telerobot through real-time simulation of a virtual mechanism**
Joly, L.D.; Andriot, C.
Robotics and Automation, 1995. Proceedings., 1995 IEEE International Conference on
Volume: 1 , 1995 , Page(s): 357 -362 vol.1

CNF **A coarse-fine approach to force-reflecting hand controller design**
Stocco, L.; Salcudean, S.E.
Robotics and Automation, 1996. Proceedings., 1996 IEEE International Conference on
Volume: 1 , 1996 , Page(s): 404 -410 vol.1

CNF **Tactile feedback with adaptive controller for a force-reflecting haptic display. 1. Design**
Hasser, C.J.; Daniels, M.W.
Biomedical Engineering Conference, 1996., Proceedings of the 1996 Fifteenth Southern , 1996 , Page(s): 526 -529

CNF **Implementation of stiff virtual walls in force-reflecting interfaces**
Colgate, J.E.; Grafing, P.E.; Stanley, M.C.; Schenkel, G.
Virtual Reality Annual International Symposium, 1993., 1993 IEEE , 1993 , Page(s): 202 -208

CNF **Design of a high performance haptic interface to virtual environments**
Millman, P.A.; Stanley, M.; Colgate, J.E.
Virtual Reality Annual International Symposium, 1993., 1993 IEEE , 1993 , Page(s): 216 -222

CNF **Passivity of a Class of Sampled-Data Systems: Appliation to Haptic Interfaces**
Colgate, J.E.; Schenkel, G.
American Control Conference, 1994
Volume: 3 , Page(s): 3236 -3240

CNF **Tactile feedback with adaptive controller for a force-reflecting haptic display. 2. Improvements and evaluation**
Hasser, C.J.; Daniels, M.W.
Biomedical Engineering Conference, 1996., Proceedings of the 1996 Fifteenth Southern , 1996 , Page(s): 530 -533

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CNF	TOC	PDF	**Error burst metrics for failure trajectory analysis** *Butler, R.A.; Cochrane, P.; Massie, J.Z.* International Transmission System, IEE Colloquium on , 1994 , Page(s): 10/1 -10/4
CNF	TOC	PDF	**Space Systems Requirements and Issues: The Next Decade** *Borger, W.U.; Massie, L.D.* Energy Conversion Engineering Conference, 1990. IECEC-90. Proceedings of the 25th Intersociety Volume: 1 , Page(s): 1 -5
CNF	TOC	PDF	**Present ability of commercial molecular beam epitaxy** *Bacher, K.; Massie, S.; Hartzel, D.; Stewart, T.* Indium Phosphide and Related Materials, 1997., International Conference on , 1997 , Page(s): 351 -352
CNF	TOC	PDF	**IR retinal vision processor hybrid IC** *Curzan, J.; Adams, A.; Huynh, B.; Massie, M.* Solid-State Circuits Conference, 1994. Digest of Technical Papers. 41st ISSCC., 1994 IEEE International , 1994 , Page(s): 132 -133
CNF	TOC	PDF	**Viscoelastic measurements in soft tissue** *Ostrander, L.E.; Massi, M.; Cui, W.; Lee, B.* Bioengineering Conference, 1989., Proceedings of the 1989 Fifteenth Annual Northeast , 1989 , Page(s): 209
CNF	TOC	PDF	**Optimal LS IIR filter design for music analysis/synthesis** *Stonick, V.L.; Massie, D.* Circuits and Systems, 1992. ISCAS '92. Proceedings., 1992 IEEE International Symposium on Volume: 5 , 1992 , Page(s): 2405 -2408 vol.5
CNF	TOC	PDF	**ARMA filter design for music analysis/synthesis** *Stonick, V.L.; Massie, D.* Acoustics, Speech, and Signal Processing, 1992. ICASSP-92., 1992 IEEE International Conference on Volume: 2 , 1992 , Page(s): 253 -256 vol.2

PER **Future trends in space power technology**
Massie, L.D.
IEEE Aerospace and Electronics Systems Magazine
Volume: 6 11 , Nov. 1991 , Page(s): 8 -13

PER **Space power systems requirements and issues: the next decade**
Massie, L.D.
IEEE Aerospace and Electronics Systems Magazine
Volume: 5 12 , Dec. 1990 , Page(s): 4 -9

PER **A tangible goal for 3D modeling**
Massie, T.
IEEE Computer Graphics and Applications
Volume: 18 3 , May-June 1998 , Page(s): 62 -65

PER **End-point detection of polymer etching using Langmuir probes**
de Castro, R.M.; Verdonck, P.; Pisani, M.B.; Mansano, R.D.; Cirino, G.A.; Maciel, H.S.; Massi, M.
Plasma Science, IEEE Transactions on
Volume: 28 3 , June 2000 , Page(s): 1043 -1049

PER **Lightweight power bus for a baseload nuclear reactor in space**
Oberly, C.E.; Massie, L.D.; Hoffmann, D.J.
Magnetics, IEEE Transactions on
Volume: 25 2 , March 1989 , Page(s): 1803 -1806

PER **9-/spl mu/m cutoff 256/spl times/256 GaAs/Al/sub x/Ga/sub 1-x/As quantum well infrared photodetector hand-held camera**
Gunapala, S.D.; Liu, J.K.; Park, J.S.; Sundaram, M.; Shott, C.A.; Hoelter, T.; True-Lon Lin; Massie, S.T.; Maker, P.D.; Muller, R.E.; Sarusi, G.
Electron Devices, IEEE Transactions on
Volume: 44 1 , Jan. 1997 , Page(s): 51 -57

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     FILE 'USPATFULL, INSPEC, EUROPATFULL' ENTERED AT 13:56:45 ON 16 MAR 2001
L1          585 S HAPTIC INTERFACE
L2          340 S L1 AND FORCE
L3           72 S L2 AND REFLECT?
L4           28 S L3 AND FREEDOM#
L5            9 S L4 AND GIMBAL?

=> D L5 1-9 IBIB ABS


L5   ANSWER 1 OF 9  USPATFULL
ACCESSION NUMBER:       2001:30232  USPATFULL
TITLE:                  Active joystick with optical positions sensor
INVENTOR(S):            Salcudean, Septimiu E., 4338 West 2nd Avenue,
                        Vancouver, B.C. V6R 1K3, Canada
                        Parker, Niall R., 289 McCallum Road, RR #5,
Abbotsford,
                        B.C.V2S 4N5, Canada

                             NUMBER        DATE
                        ---------------- --------
PATENT INFORMATION:     US 6195083       20010227
APPLICATION INFO.:      US 1998-190000   19981112  (9)

                               NUMBER        DATE
                        ------------------ ---------
PRIORITY INFORMATION:   US 1997-65787      19971114 (60)
DOCUMENT TYPE:          Utility
PRIMARY EXAMINER:       Hjerpe, Richard A.
ASSISTANT EXAMINER:     Eisen, Alexander
LEGAL REPRESENTATIVE:   Rowley, C. A.
NUMBER OF CLAIMS:       17
EXEMPLARY CLAIM:        1
NUMBER OF DRAWINGS:     11 Drawing Figure(s); 11 Drawing Page(s)
LINE COUNT:             805
AB     A joystick composed of a stator formed by an outer cage forming an
inner
       cubic compartment containing an inner cube oriented with its wall
spaced
       from and substantially parallel corresponding wall of the compartment.
       Opposed magnets are position in cooperating relationship on opposed
       walls of the compartment and cube and define a gap therebetween. A
       floater formed by a plurality of flat actuating coils, one positioned
in
       each gap and each thinner than the width of the gap in which it is
       received. Preferably the ratio of coil thickness to gap width is at
       least 1:3. Preferably an optical position sensor is used to monitor the
       relative position of the flotor and stator and is composed of at least
       one linear light position sensor mounted on one of the stator and
flotor
       and a plurality of planar light beams arranged at an angle to each
other
       on the other of the stator and flotor and directed to the linear light
       position sensor(s) so that the light beams traverse the linear light
```

L5 ANSWER 2 OF 9 USPATFULL
ACCESSION NUMBER: 2000:170419 USPATFULL
TITLE: Inertial orientation tracker having automatic drift compensation for tracking human head and other similarly sized body
INVENTOR(S): Foxlin, Eric M., Cambridge, MA, United States
PATENT ASSIGNEE(S): Massachusetts Institute of Technology, Cambridge, MA, United States (U.S. corporation)

	NUMBER	DATE	
PATENT INFORMATION:	US 6162191	20001219	
APPLICATION INFO.:	US 1998-153213	19980914	(9)

DOCUMENT TYPE: Utility
PRIMARY EXAMINER: Rimell, Sam
LEGAL REPRESENTATIVE: Weissburg, Steven J.
NUMBER OF CLAIMS: 4
EXEMPLARY CLAIM: 1
NUMBER OF DRAWINGS: 19 Drawing Figure(s); 14 Drawing Page(s)
LINE COUNT: 1370

AB A self contained sensor apparatus generates a signal that corresponds to at least two of the three orientational aspects of yaw, pitch and roll of a human-scale body, relative to an external reference frame. A sensor generates first sensor signals that correspond to rotational accelerations or rates of the body about certain body axes. The sensor may be mounted to the body. Coupled to the sensor is a signal processor for generating orientation signals relative to the external reference frame that correspond to the angular rate or acceleration signals. The first sensor signals are impervious to interference from electromagnetic, acoustic, optical and mechanical sources. The sensors may be rate sensors. An integrator may integrate the rate signal over time. A drift compensator is coupled to the rate sensors and the integrator. The drift compensator may include a gravitational tilt sensor or a magnetic field sensor or both. A verifier periodically measures the orientation of the body by a means different from the drift sensitive rate sensors. The verifier may take into account characteristic features of human motion, such as stillness periods. The drift compensator may be, in part, a Kalman filter, which may utilize statistical data about human head motion.

L5 ANSWER 3 OF 9 USPATFULL
ACCESSION NUMBER: 1999:51405 USPATFULL
TITLE: **Force reflecting haptic interface**
INVENTOR(S): Massie, Thomas H, Vanceburg, KY, United States
Salisbury, Jr., J. Kenneth, Cambridge, MA, United States
PATENT ASSIGNEE(S): Massachusetts Institute of Technology, Cambridge, MA, United States (U.S. corporation)

	NUMBER	DATE	
PATENT INFORMATION:	US 5898599	19990427	
APPLICATION INFO.:	US 1996-771484	19961223	(8)

RELATED APPLN. INFO.: Continuation of Ser. No. US 1993-130639, filed on 1 Oct 1993, now patented, Pat. No. US 5625576, issued on 29 Apr 1997

PRIMARY EXAMINER: Cosimano, Edward R.
LEGAL REPRESENTATIVE: Testa, Hurwitz & Thibeault, LL
NUMBER OF CLAIMS: 52
EXEMPLARY CLAIM: 1
NUMBER OF DRAWINGS: 16 Drawing Figure(s); 10 Drawing Page(s)
LINE COUNT: 2238

AB An apparatus and method for physically exchanging a **force** with a user in a user-local environment. The apparatus includes a user connection element and a linkage physically linking the user connection element to a reference. The linkage provides at least six independent degrees of **freedom** to the user connection element. The linkage has an actuator system which powers at least three degrees of **freedom** of the user connection element, while at least three degrees of **freedom** remain unpowered. The method includes providing an apparatus which includes a user connection element and a linkage physically linking the user connection element to a reference, the linkage providing at least six independent degrees of **freedom** to the user connection element. The linkage of the apparatus provided has an actuator system which powers at least three of the six independent degrees of **freedom** relative to the reference. The method further includes connecting the user connection element to a body member of a user and powering at least three of the six independent degrees of **freedom**.

L5 ANSWER 4 OF 9 USPATFULL
ACCESSION NUMBER: 1998:111471 USPATFULL
TITLE: **Force-reflecting** surgical instrument and positioning mechanism for performing minimally invasive surgery with enhanced dexterity and sensitivity
INVENTOR(S): Madhani, Akhil J., Cambridge, MA, United States
Salisbury, J. Kenneth, Cambridge, MA, United States
PATENT ASSIGNEE(S): Intuitive Surgical, Inc., Mountain View, CA, United States (U.S. corporation)

	NUMBER	DATE	
PATENT INFORMATION:	US 5807377	19980915	
APPLICATION INFO.:	US 1997-858048	19970516	(8)

	NUMBER	DATE
PRIORITY INFORMATION:	US 1996-17981	19960520 (60)

DOCUMENT TYPE: Utility
PRIMARY EXAMINER: Buiz, Michael
ASSISTANT EXAMINER: Woo, Julian W.
LEGAL REPRESENTATIVE: Townsend and Townsend and Crew LLP
NUMBER OF CLAIMS: 21
EXEMPLARY CLAIM: 1
NUMBER OF DRAWINGS: 13 Drawing Figure(s); 11 Drawing Page(s)
LINE COUNT: 1055

AB An articulated surgical instrument for enhancing the performance of minimally invasive surgical procedures is coupled to a positioning mechanism for supporting and moving the surgical instrument. The positioning mechanism mounts to an operating room table. The instrument has a high degree of dexterity, low friction, low inertia and good **force reflection** and the positioning mechanism provides a large range of motion to the instrument. The system is operated according to a macro-micro actuation scheme which allows for a large range of motion of the surgical end effector and also allows for sensitive **force** feedback to a master controller by reducing the measured inertia of the slave system. The macro-micro actuation

force scaling be‑ ‑en the instrument and the mast‑ ‑controller.

L5 ANSWER 5 OF 9 USPATFULL
ACCESSION NUMBER: 1998:111384 USPATFULL
TITLE: Inertial orientation tracker apparatus method having automatic drift compensation for tracking human head and other similarly sized body
INVENTOR(S): Foxlin, Eric M., Cambridge, MA, United States
PATENT ASSIGNEE(S): Massachusetts Institute of Technology, Cambridge, MA, United States (U.S. corporation)

	NUMBER	DATE	
PATENT INFORMATION:	US 5807284	19980915	
APPLICATION INFO.:	US 1997-882650	19970625	(8)

RELATED APPLN. INFO.: Division of Ser. No. US 1994-261364, filed on 16 Jun 1994, now patented, Pat. No. US 5645077
DOCUMENT TYPE: Utility
PRIMARY EXAMINER: Apley, Richard J.
ASSISTANT EXAMINER: Yu, Justine R.
LEGAL REPRESENTATIVE: Weissburg, Steven J.
NUMBER OF CLAIMS: 13
EXEMPLARY CLAIM: 9
NUMBER OF DRAWINGS: 19 Drawing Figure(s); 14 Drawing Page(s)
LINE COUNT: 1482

AB A self contained sensor apparatus generates a signal that corresponds to at least two of the three orientational aspects of yaw, pitch and roll of a human-scale body, relative to an external reference frame. A sensor generates first sensor signals that correspond to rotational accelerations or rates of the body about certain body axes. The sensor may be mounted to the body. Coupled to the sensor is a signal processor for generating orientation signals relative to the external reference frame that correspond to the angular rate or acceleration signals. The first sensor signals are impervious to interference from electromagnetic, acoustic, optical and mechanical sources. The sensors may be rate sensors. An integrator may integrate the rate signal over time. A drift compensator is coupled to the rate sensors and the integrator. The drift compensator may include a gravitational tilt sensor or a magnetic field sensor or both. A verifier periodically measures the orientation of the body by a means different from the drift sensitive rate sensors. The verifier may take into account characteristic features of human motion, such as stillness periods. The drift compensator may be, in part, a Kalman filter, which may utilize statistical data about human head motion.

L5 ANSWER 6 OF 9 USPATFULL
ACCESSION NUMBER: 1998:55256 USPATFULL
TITLE: Gyro-stabilized platforms for **force**-feedback applications
INVENTOR(S): Roston, Gerald P., Whitmore Lake, MI, United States
Jacobus, Charles J., Ann Arbor, MI, United States
PATENT ASSIGNEE(S): Cybernet Systems Corporation, Ann Arbor, MI, United States (U.S. corporation)

	NUMBER	DATE	
PATENT INFORMATION:	US 5754023	19980519	
APPLICATION INFO.:	US 1996-736016	19961022	(8)

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PRIORITY INFORMATION: US 1995-5861 19951026 (6
DOCUMENT TYPE: Utility
PRIMARY EXAMINER: Ro, Bentsu
LEGAL REPRESENTATIVE: Gifford, Krass,Groh, Sprinkle, Patmore, Anderson&Citkowski
NUMBER OF CLAIMS: 24
EXEMPLARY CLAIM: 1
NUMBER OF DRAWINGS: 25 Drawing Figure(s); 14 Drawing Page(s)
LINE COUNT: 1372

AB **Force** feedback in large, immersive environments is provided by device which a gyro- stabilization to generate a fixed point of leverage for the requisite **forces** and/or torques. In one embodiment, one or more orthogonally oriented rotating gyroscopes are used to provide a stable platform to which a **force-reflecting** device can be mounted, thereby coupling reaction **forces** to a user without the need for connection to a fixed frame. In one physical realization, a rigid handle or joystick is directly connected to the three-axis stabilized platform and using an inventive control scheme to modulate motor torques so that only the desired **forces** are felt. In an alternative embodiment, a reaction sphere is used to produce the requisite inertial stabilization. Since the sphere is capable of providing controlled torques about three arbitrary, linearly independent axes, it can be used in place of three reaction wheels to provide three-axis stabilization for a variety of space-based and terrestrial applications.

L5 ANSWER 7 OF 9 USPATFULL
ACCESSION NUMBER: 97:58157 USPATFULL
TITLE: Inertial orientation tracker apparatus having automatic drift compensation for tracking human head and other similarly sized body
INVENTOR(S): Foxlin, Eric M., Cambridge, MA, United States
PATENT ASSIGNEE(S): Massachusetts Institute of Technology, Cambridge, MA, United States (U.S. corporation)

	NUMBER	DATE	
PATENT INFORMATION:	US 5645077	19970708	
APPLICATION INFO.:	US 1994-261364	19940616	(8)

DOCUMENT TYPE: Utility
PRIMARY EXAMINER: Rimell, Sam
LEGAL REPRESENTATIVE: Weissburg, Steven J.
NUMBER OF CLAIMS: 44
EXEMPLARY CLAIM: 1
NUMBER OF DRAWINGS: 19 Drawing Figure(s); 14 Drawing Page(s)
LINE COUNT: 1553

AB A self contained sensor apparatus generates a signal that corresponds to at least two of the three orientational aspects of yaw, pitch and roll of a human-scale body, relative to an external reference frame. A sensor generates first sensor signals that correspond to rotational accelerations or rates of the body about certain body axes. The sensor may be mounted to the body. Coupled to the sensor is a signal processor for generating orientation signals relative to the external reference frame that correspond to the angular rate or acceleration signals. The first sensor signals are impervious to interference from electromagnetic, acoustic, optical and mechanical sources. The sensors

time. A drift compensator is coupled to the rate sensors and the integrator. The drift compensator may include a gravitational tilt sensor or a magnetic field sensor or both. A verifier periodically measures the orientation of the body by a means different from the drift sensitive rate sensors. The verifier may take into account characteristic features of human motion, such as stillness periods. The drift compensator may be, in part, a Kalman filter, which may utilize statistical data about human head motion.

L5 ANSWER 8 OF 9 USPATFULL

ACCESSION NUMBER: 97:36834 USPATFULL
TITLE: **Force reflecting haptic interface**
INVENTOR(S): Massie, Thomas H., Vanceburg, KY, United States
Salisbury, Jr., J. Kenneth, Cambridge, MA, United States
PATENT ASSIGNEE(S): Massachusetts Institute of Technology, Cambridge, MA, United States (U.S. corporation)

	NUMBER	DATE	
PATENT INFORMATION:	US 5625576	19970429	
APPLICATION INFO.:	US 1993-130639	19931001	(8)

DOCUMENT TYPE: Utility
PRIMARY EXAMINER: Cosimano, Edward R.
LEGAL REPRESENTATIVE: Weissburg, Steven J.
NUMBER OF CLAIMS: 42
EXEMPLARY CLAIM: 11
NUMBER OF DRAWINGS: 17 Drawing Figure(s); 10 Drawing Page(s)
LINE COUNT: 2143

AB A connection element such as a thimble connects to a user's body member and, through a linkage, to a ground reference. The apparatus physically exchanges a **force** with a user in an environment local to the user. The linkage powers at least three independent **freedoms** of the connection element relative to the reference. It also maintains at least one independent **freedom** of the connection element relative to the reference free of power. Up to three independent **freedoms** of the connection element may be maintained free of power, and up to five independent **freedoms** may be powered. A **gimbal** connects the **gimbal** to the linkage. Zero, one or two of the **gimbal** axes may be powered. A five bar linkage connects the connection element to a counter-balance that also includes two actuators. A third actuator connects the five bar linkage to the reference. The two actuators of the counterbalance may be connected to the next link in the chain to the reference through a single cable. Signal processing equipment powers the actuators to deliver a signal at the connection element that represents a virtual situation generated by a programmed computer, or physical conditions in a remote environment. A virtual switch presents to the user the **force** and displacement relationship of a spring switch. A virtual bristled brush presents the **force** and displacement relationship of such a brush, while also changing the virtual environment to **reflect** the user's changes in location.

L5 ANSWER 9 OF 9 USPATFULL

ACCESSION NUMBER: 96:119144 USPATFULL
TITLE: **Force reflecting haptic interface**
INVENTOR(S): Massie, Thomas H., Vanceburg, KY, United States
Salisbury, Jr., J. Kenneth, Cambridge, MA, United

PATENT ASSIGNEE(S): Massachusetts Institute of Tec[illegible]logy, Cambridge, MA, United States (U.S. corporatio[illegible]

	NUMBER	DATE
PATENT INFORMATION:	US 5587937	19961224
APPLICATION INFO.:	US 1995-429266	19950425 (8)

RELATED APPLN. INFO.: Continuation of Ser. No. US 1993-130639, filed on 1 Oct 1993

DOCUMENT TYPE: Utility
PRIMARY EXAMINER: Cosimano, Edward R.
LEGAL REPRESENTATIVE: Weissburg, Steven J.
NUMBER OF CLAIMS: 9
EXEMPLARY CLAIM: 1
NUMBER OF DRAWINGS: 17 Drawing Figure(s); 10 Drawing Page(s)
LINE COUNT: 1912

AB A connection element such as a thimble connects to a user's body member, through a linkage, to a ground reference. The apparatus physically exchanges a **force** with a user in an environment local to the user. The linkage powers at least three independent **freedoms** of the connection element relative to the reference. It also maintains at least one independent **freedom** of the connection element relative to the reference free of power. Up to three independent **freedoms** of the connection element may be maintained free of power, and up to five independent **freedoms** may be powered. A **gimbal** connects the **gimbal** to the linkage. Zero, one or two of the **gimbal** axes may be powered. A five bar linkage connects the connection element to a counter-balance that also includes two actuators. A third actuator connects the five bar linkage to the reference. The two actuators of the counterbalance may be connected to the next link in the chain to the reference through a single cable. Signal processing equipment powers the actuators to deliver a signal at the connection element that represents a virtual situation generated by a programmed computer, or physical conditions in a remote environment. A virtual switch presents to the user the **force** and displacement relationship of a spring switch. A virtual bristled brush presents the **force** and displacement relationship of such a brush, while also changing the virtual environment to **reflect** the user's changes in location.